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Improving spectral resolution of SERS using moving Ag nanopillar substrate

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The detection of complex molecular species using surface-enhanced Raman scattering (SERS) spectroscopy can induce dissociation of the molecules that reduces the reproducibility of the measurement. Here, the issue is addressed by moving SERS substrates during measurements in the perpendicular axes to the laser.

The problem with conventional SERS methods is that a nearly diffraction-limited laser focal spot and a high laser power are required to obtain a high spectral resolution. However, the increased power density at the substrate leads to heating and can damage the analyte molecule [1]. Other effects, such as photo-induced changes, photo-bleaching or photo desorption, can also occur. The solution is often either to increase the size of the laser spot or reduce the laser power, both resulting in lower spectral resolution.

When the substrate is moving while recording SERS spectra, the laser spot changes position continuously which reduces substrate heating. By taking advantage of a highly uniform SERS substrate and assuming that the surface is uniformly covered by at least one monolayer, the substrate is moved in two axes so the focus point of the laser is always on the surface of the SERS substrate. When moving the substrate, the SERS spectra exhibit an improved spectral resolution, meaning that the Raman scattering peaks have a decreased full width at half maximum (FWHM) compared to measurements performed using static SERS substrates. The new experimental technique enables better characterization and thereby identification of target molecules, see Figure 1. The SERS spectra of 2,2';5,2''-terthiophene improves drastically when measuring on a moving substrate of approximately 0.01m/s revealing a set of otherwise hidden peaks. The insert illustrates that the FWHM also improves of already visible peaks.

Furthermore, this method appears to give molecules, which are likely to dissociate due to the energy of the laser, more stability by spreading the heat over a larger area while measuring. This means making molecules, which were unmeasurable due to dissociation, measurable with this method.

The measurements are done with a SERS substrate of leaning silver coated silicon nanopillars shown in Figure 2. These pillars are easy and fast to fabricate with a one-step dry-etching process and a thin-film layer deposition of metal – typically Ag or Au. Furthermore these nanopillars show great enhancement compared to other substrates [2].

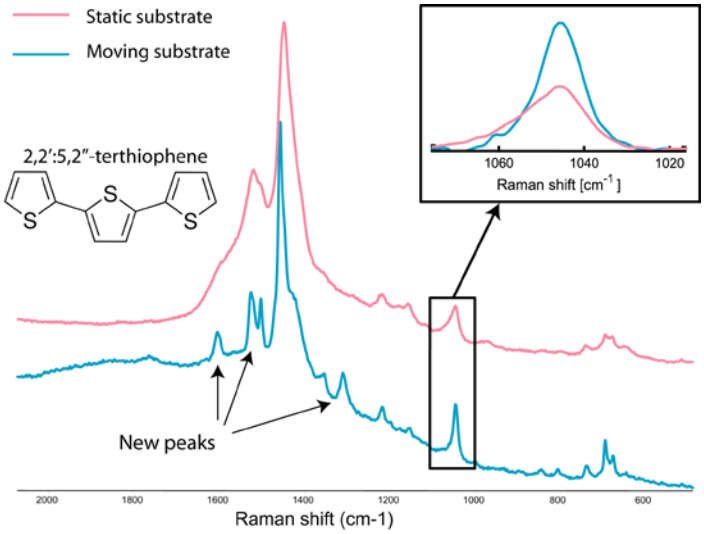

Figure 1 SERS measurements of 1mM 2,2':5,2''-terthiophene with a speed of ~0.01m/s, 1second integration time, 50X objective, 0.5mW and 532nm laser on leaning silver coated silicon nanopillars. The FWHM improves when moving the substrate while measuring. Additionally, new peaks appear in the spectra.

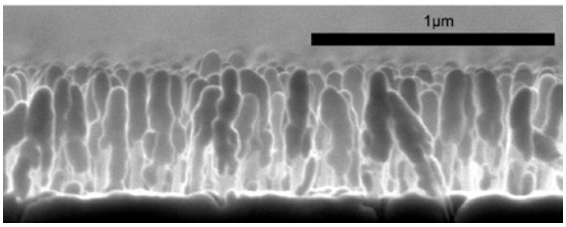

Figure 2 Silver coated silicon nanopillars for surface enhanced Raman spectroscopy. The pillars are wetted and when the solvent evaporates the surface tension pulls the pillars together forming clusters and potential hotspots.

ACKNOWLEDGMENTS

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